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DESCRIPTION OF *BATHYSCIADIUM XYLOPHAGUM*  
WARÉN & CARROZZA, SP.N. AND COMMENTS ON *ADDISONIA*  
*EXCENTRICA* (TIBERI) TWO MEDITERRANEAN COCCULINIFORM  
GASTROPODS

Key words: Mediterranean, Tuscan Sea, Azores, Portugal, new records, Gastropoda, Cocculiniformia, Bathysciadiidae, *Bathysciadium*, Addisoniidae, *Addisonia*.

**Abstract**

*Bathysciadium costulatum* (Locard, 1897) (Bathysciadiidae, Cocculiniformia, Gastropoda), the type species of *Bathysciadium*; *B. pacificum* Dall, 1908, type species of *Bathypelta* Moskalev, 1971; and *Bonus petrochenkoi* Moskalev, 1973, type species of *Bonus* Moskalev, 1973; are redescribed and, as a result of the new information, *Bathypelta* and *Bonus* are considered synonyms of *Bathysciadium*. *Bathysciadium xylophagum* Warén & Carrozza, sp.n. is described from sunken driftwood in the Mediterranean.

*Addisonia excentrica* (Tiberi, 1855) (Addisoniidae, Cocculiniformia, Gastropoda) is recorded from seamounts south of the Azores. The radula, shell, and soft parts are figured and compared with those of *A. paradoxa* Dall, 1882 from the western Atlantic. Previous assumptions of conspecificity are substantiated by this new, geographically intermediate, material and a detailed examination of radulae.

**Riassunto**

Vengono qui ridescritti *Bathysciadium costulatum* (Locard, 1897) (Bathysciadiidae, Cocculiniformia Gastropoda), sp. tipo di *Bathysciadium*; *B. pacificum* Dall, 1908, specie tipo di *Bathypelta* Moskalev, 1971 e *Bonus petrochenkoi* Moskalev, 1973, specie tipo di *Bonus* Moskalev, 1973. Come risulta da nuove informazioni sia *Bathypelta* che *Bonus* sono da considerarsi sinonimi di *Bathysciadium*. Viene descritto *Bathysciadium xylophagum* Warén & Carrozza, sp. n., trovato su legno detritico sommerso in Mediterraneo.

*Addisonia excentrica* (Tiberi, 1855) (Addisoniidae, Cocculiniformia, Gastropoda) proviene dai monti oceanici a sud delle isole Azzorre. Radula, conchiglia e parti molli sono state illustrate e confrontate con quelle di *A. paradoxa* Dall, 1882 del West Atlantico. Le precedenti supposizioni di conspecificità sono confermate da questo nuovo materiale geograficamente intermedio e dal dettagliato esame radulare

**Introduction**

Limpet shaped shells have evolved several times among the gastropods and in all major groups. It seems invariably to be the result of life on a firm substrate of various kinds (stones, shells, algae, wood, tubes of animals, or

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animals like crabs and sponges). This specialisation leads to certain parallel adaptations in the soft parts, for example simplification of the foot, reduction of sensory organs, as well as the simplified shell.

When only shells are available of such gastropods, classification often presents great problems. The protoconch is of some use in certain taxa, but several groups lose the protoconch very early in their life (many Patelligastropoda (WARÉN 1988) and Lepetelloidea (see below)). Internal muscle scars are sometimes of help but often too poorly developed to be of use, especially in thin-shelled deep-sea species. Frequently the final result is that one has to rely on intuition when many of these species are encountered.

The deep-sea archaeogastropod limpets can present particular problems to malacologists, especially in the absence of the soft parts. Usually these limpets have highly apomorphic radulae, presumably reflecting their specialised feeding on various kinds of substrates.

I will here provide some new information about two species previously not, or poorly, known from the Mediterranean. I will also present some details on related species in order to better understand their relations and systematic position, hoping that this may be of future use for a better understanding of their groups.

### **Material and methods**

The material used for this paper originates from various sources. The Mediterranean specimens have been obtained from trawl refuse. For comparison I have used museum specimens from the following collections:

MNHN -- Museum National d'Histoire Naturelle, Paris.

SMNH -- Swedish Museum of Natural History, Stockholm.

USNM -- National Museum of Natural History, Washington D.C.

ZMMSU -- Zoological Museum of the Moscow State University, Moscow.

Specimens of varying fixation and stored in alcohol were critical-point dried in carbon dioxide, via acetone. In some cases living animals were examined under a stereomicroscope during deep sea cruises.

#### Systematics

Class GASTROPODA

PROSOBRANCHIA

Order COCCULINIFORMIA

Superfamily LEPETELLOIDEA Dall, 1882

Family BATHYSCIADIIDAE Dautzenberg & Fischer, 1899

In addition to the genera discussed in this paper, WARÉN (1993) described a new genus, *Xenodonta* in the Bathysciadiidae, based on similarities in the protoconch and radula. The systematic position of that genus is, however, very uncertain. One species of *Xenodonta* lives on shells of a species of *Capulus* (Capulidae), evidently feeding on the periostracum.

Genus *Bathysciadium* Dautzenberg & Fischer, 1899

*Bathysciadium* DAUTZENBERG & FISCHER, 1899:207, type species *B. conicum* Dautzenberg & Fischer, 1899 (*B. costulatum* (Locard, 1897)), by monotypy (on squid beaks, bathyal, the Azores).

*Bathypelta* MOSKALEV, 1971: 59, type species *Bathysciadium pacificum* Dall, 1908, by original designation (on squid beaks, abyssal, off Peru).

*Bonus* MOSKALEV, 1973:b1301, type species *Bonus petrochenkoi* Moskaev, 1973, by original designation (on squid beaks, Kuril-Kamchatka Trench, abyssal).

Remarks. DAUTZENBERG & FISCHER (1899, 1940) described the shell of *Bathysciadium conicum* and PELSENEER (1899, 1940) gave some details on the anatomy in an appended paper.

*Bathysciadium pacificum* Dall, 1908 was described from a cephalopod beak found off Peru at a depth of 4044 m. The shell of this species differs in being considerably larger than *B. costulatum*, 5-7 mm (1.5-2 mm in *B. costulatum*), and in having a tilted apex. THIELE (1908) described the anatomy based on specimens from the type series and noted profound discrepancies between his material and PELSENEER's report on *B. conicum*. However, he also noticed a great similarity in the radula, shell and external features of the soft parts and concluded that the small size of *B. costulatum* (1.5 mm) had caused problems for PELSENEER and that the two species nevertheless were closely related.

Despite this, MOSKALEV (1971) made a new genus, *Bathypelta*, based on the discrepancies between PELSENEER's and THIELE's descriptions and his own observations on *Bathysciadium pacificum*. He also added to the confusion by making a new family and superfamily for *Bathypelta*.

To be able to evaluate the differences mentioned by THIELE, PELSENEER, and MOSKALEV I examined LOCARD's, DAUTZENBERG & FISCHER's, DALL's, and MOSKALEV's bathysciadiid material as well as several undescribed species of the group.

This study showed that there are numerous species in the Bathysciadiidae that differ in the shape and size of the shell, development of the periostracum, development of oral "suckers" and morphology of the male reproductive organ. The radula is virtually identical in all species I have examined and classified in *Bathysciadium* and therefore of no use except to recognise the generic position. I have seen up to three species on a single squid beak (from the western Pacific).

As far as I can see from examination of the type specimens of *Lepeta costulata*, *Bathysciadium conicum* and comparison with more recent material, they belong to the same species.

Compared with syntypes of *B. costulatum* (Fig. 1 A-B) the shell of *B. conicum* is of the same size and shape, and has the same arrangement of the

periostracal ridges. I have not seen the protoconch of this species, but that of a very similar species, from a squid beak from deep water off Reunion Island in the Indian Ocean, is illustrated here (Fig. 2). SEM examination of critical-point dried type specimens of *B. conicum* (Fig. 3 B-C), was not useful for morphological investigations, because of the poor condition of the types which apparently had been stored too long in weak alcohol. It did, however, fail to reveal differences from a well preserved specimen from off West Africa (DISCOVERY station 7991). I figure the best of the syntypes (Fig. 3 B-C) and the DISCOVERY specimen (Figs 3 A, 4). This material makes it possible to redescribe type species of *Bathysciadium*, which is presented under that species heading. The types of *B. costulatum* were too poorly preserved for detailed examination of the soft parts, except the radula.

I have examined the remaining type material of *B. pacificum* in USNM, one adult shell, the cephalopod beak to which it was attached and a few very young dried specimens still attached to the beak. (There are also serial sections in the Humboldt Museum in Berlin; these have not been examined, but will form the base for an anatomical redescription by G. HASZPRUNAR, Munich.) I have also examined several specimens from MOSKALEV's material. It is obvious from THIELE's description and my examination that THIELE's and MOSKALEV's specimens of *B. pacificum* stand out among the species I have seen by having a relatively very large gill, at least twice as large as in any of the half dozen additional species I have examined. The radula of MOSKALEV's specimens (Figs 5 A, 6 A) does not differ from THIELE's drawing more than could be expected from light microscopical examination; nor does it differ noticeably from the SEM examination of the radula of a young syntype of *B. pacificum*. The soft parts of a critical-point dried specimen from MOSKALEV's material are illustrated (Fig. 7). Comparing this and THIELE's description, I can see no reason to separate DALL's and MOSKALEV's specimens and redescribe *B. pacificum* based on MOSKALEV's material:

**Redescription of *Bathysciadium pacificum*.** Shell large for the genus, up to 7.5 mm in diameter, conical, with slightly convex anterior and concave posterior profile, rather sturdy, with about 20 radially arranged periostracal ridges. The height is about 2/3 of the length. The apex is central and becomes more inclined backwards with increasing size. The sculpture consists of irregularly scattered growth lines, not perfectly concentric because of the change in the tilt of the apex.

Soft parts (Fig. 7). The foot is small and sucker like, its breadth corresponds to about 60% of the width of the contracted soft parts. It is thin with a furrow along the margin, lacks a propodium, and has no appendages. The head is proportionally large, with a broad, apically expanded snout. The apical part of the snout forms a well defined, flat area with a central mouth and a large sucker like shield at each side. The head has two short and stubby cephalic tentacles of equal size, the right one with a latero-dorsal penis, much

larger than the tentacle. The penis (Fig. 7 C) has a ventral sperm gutter, which continues as a ciliated tract along the neck (Fig. 7 B) and into the pallial cavity. The pallial skirt is equipped with numerous gutter like tentacles corresponding to the periostracal ridges. The gill, with at least 25 leaflets, starts centrally in the anterior part of the pallial cavity continues over to the right side, beside the neck and along the pallial furrow to the midpoint of the foot. Most free body surfaces are covered by scattered tufts of cilia, especially the sides of the foot, but their exact distribution is difficult to evaluate because of damage to some parts of the epithelium.

**Radula** (Figs 5 A, 6 A). The central field is reduced but maintains a shield like structure in the central field of each transverse row, occasionally and especially in the centre and sides, slightly protruding from the radular membrane. The first recognisable tooth is a tall, laterally flattened structure on a slightly wider base. Next element is low and irregularly shaped, partly concealed between the surrounding teeth. It seems mainly to act as a joint between teeth number 1 and 3. The third tooth is large and sturdy but rather prone to damage by KOH and cracks frequently. Figure 5A gives a good idea about its shape. On its outer side and to some extent covering its outer slope are 3-5 indistinctly set off lamellae which may be a reduced tooth (teeth?).

It is possible that tooth number 3 actually is the result of fusion of two or more teeth; it has a tendency to break up in the same places in all specimens and species, but this can not be verified.

MOSKALEV (1971, 1973) took THIELE'S and PELSENEER'S (1899) descriptions *ad notam* and used two discrepancies for his decision to place *B. pacificum* and *B. costulatum* in different superfamilies:

---"*B. pacificum* has a large gill, - *B. costulatum* lacks a gill." My examination shows that *B. costulatum* actually has a gill though it is small and was evidently overlooked by PELSENEER.

---"*B. pacificum* has a single left kidney, - *B. costulatum* has two kidneys of which the right is incorporated in the reproductive system." HASZPRUNAR (1988) did not find that a right kidney is incorporated in the reproductive system, which supports THIELE'S assumption that PELSENEER'S statement was erroneous.

Therefore none of MOSKALEV'S assumed differences remain and I can see no other reason for maintaining the family level taxa he introduced. For an evaluation of the use of more than one generic name among the species with a "*Bathysciadium* type" radula, more information on *Bonus petrochenkoi* is needed, and I take this occasion to redescribe it based on specimens kindly sent by D. IVANOV (ZMMSU).

**Redescription** of *Bonus petrochenkoi*. Shell (Fig. 1 C-D) of small size for the genus, up to 2.7 mm in diameter; conical, with convex anterior and concave posterior slopes, fragile, with about 35 radially arranged periostracal ridges. Height about 3/4 of length. The apex is slightly posterior and its tilt

changes when the shell enlarges, so the apex becomes more and more inclined backwards with increasing size. The sculpture consists of irregularly scattered growth lines, not perfectly concentric, due to the change of the inclination of the apex with increasing shell size.

Soft parts (Fig. 5 C-D). The foot is sucker like and its breadth corresponds to about 85% of the width of the contracted soft parts. It has a furrow along the margin, lacks a propodium, and has no appendages. The head is proportionally large, with a broad, apically expanded snout, with a rim that is less developed than in other bathysciadiids. The apical part of the snout forms a well defined, flat area with a central mouth and a shield at each side. The head has two short and stubby cephalic tentacles, the right one smaller than the left one and with a latero-dorsal penis, much larger than the tentacle. The penis has a ventral sperm gutter. The pallial skirt is equipped with indistinct papillae corresponding to the periostracal ridges. No trace of a gill was found. Most free body surfaces are covered by scattered tufts of cilia, especially the sides of the foot.

Radula (Figs 5 B, 6 C). The central field is reduced but maintains a series of irregular structures, slightly protruding from the radular membrane. No other differences were noticed compared with *B. pacificum* and *B. costulatum*.

This means that at present there are four species of which the soft parts are known, including the one described herein: *petrochenkoi*, *pacificum*, *costulatum* and *xylophagum*. These differ in the development of the gill, minor features in the shape of the male reproductive organ, the size and the shape of the shell. I have examined a few additional, undescribed species, and from them it can be added that not all species have the oral "suckers".

It is clear that *B. petrochenkoi* differs from other bathysciadiids, by the lack of a gill. Such a character, however, a simple reduction or loss of an organ in a single species, is not very informative and not useful for exploring the phylogeny.

I have not been able to find any grouping or covariation of the other characters and can therefore see no possibility of resolving the phylogeny of the group without access to better preserved material. Thus, I consider the three generic names *Bathysciadium*, *Bathypelta* and *Bonus* synonymous.

In addition to the species discussed in this paper, DALL (1927) described *Bathysciadium concentricum* from about 800 m depth, off Georgia, but the description is based on shells only, which will make it difficult to recognise this species. This is also the case with *Cocculina rotunda* DALL, 1927 from about 500 m depth off Florida, and referred to *Bathysciadium* by McLEAN & HARASEWYCH (1995).

*Bathysciadium costulatum* (Locard, 1897)  
Figs 1 A-B, 3 A-C, 4, 6 B, 8 D

*Lepeta costulata* LOCARD, 1897: 96, plate 5, figs 16-18.

*Bathysciadium conicum* DAUTZENBERG & FISCHER, 1899:207, 3 figs.

*Bathysciadium costulatum*: THIELE 1908:81-87.

Type materials. *L. costulata*, syntypes in MNHN (in alcohol, soft parts not well preserved); *B. conicum*, numerous syntypes in Musée Océanographique, Monaco, reg n° 22 5798 (dry). Type localities. *L. costulata*, Talisman 1883, dragage 118, South of the Azores, 3175 m, on a jaw of a cephalopod; *B. conicum*, off the Azores, 39°27.1'N, 33°15.3'W, 1557 m, on a jaw of a cephalopod.

Material examined: The types and numerous specimens from MONACO EXPEDITIONS stations 244 (in alcohol, poorly preserved), 616 (dry), 698 (dry), 703 (dry), from all around the Azores, 1022-1846 m. Off Spanish Sahara, DISCOVERY sta 7991, 24°12'N, 17°06'W, 1510 m, one specimen, shell lost through storage in formalin, animal critical-point dried (Figs. 3 A-C, 4).

Distribution. Around the Azores and off West Africa, in 1000-2000 m depth, only known from cephalopod beaks.

### **Redescription**

Shell (Fig. 1 A-B). Small for the genus, maximum diameter 2 mm, conical, radially symmetrical, fragile, with about 20 radially arranged periostracal ridges. The apex is central and does not change its inclination during growth. The sculpture consists of irregularly scattered, perfectly concentric growth lines.

Soft parts (Figs 3 A-C, 4). The foot is small and sucker like and its breadth corresponds to about 60% of the width of the contracted soft parts. It is thin with a furrow along the margin, lacks a propodium, and has no appendages. The head (Fig. 3 A-B) is proportionally large, with a broad, apically expanded snout. The apical part of the snout forms a well defined, flat area with a central mouth with a small sucker like shield at each side. The head has two cephalic tentacles, the left one short and stubby, the right one still shorter and with a latero-dorsal penis, much larger than the tentacle. The penis has a small dorsal bulge where it is attached and a ventral sperm gutter. The pallial skirt is equipped with 20 gutter like tentacles corresponding to the periostracal ridges and about 5 small gill leaflets at the right side, beside the neck. Most free body surfaces are covered by scattered tufts of cilia, especially the sides of the foot, but their distribution is difficult to evaluate because of damage to some parts of the epithelium.

Radula (Figs 6 B, 8 D). The central field is reduced but maintains a shield like structure centrally in each transverse row, occasionally and especially in the centre and sides, slightly protruding from the radular membrane. The first normally developed tooth is a tall, laterally flattened structure on a slightly wider base. Next element is low and irregularly shaped, partly concealed between the surrounding teeth. It seems mainly to act as a joint between teeth

number 1 and 3. The third tooth is large and sturdy but rather prone to damage by KOH and cracks frequently. Figure 8D gives a good idea about its shape. On its outer side and to some extent covering its outer slope are 3-5 indistinctly set off lamellae which may be a reduced tooth (teeth?).

Jaw absent.

Remarks. Among the species of *Bathysciadium* known from the eastern Atlantic, *B. costulatum* stands apart because of its small size and very symmetrically conical shell. I have seen a similar species from Reunion in the Indian Ocean (Fig. 2), which cannot be distinguished, but hesitate to consider it to belong to the same species.

*Bathysciadium xylophagum* sp. n. Warén & Carrozza  
Figs 9 A-B, 10 A-C, 11 A-C

Type material. Holotype SMNH 4758; 7 paratypes, coll. CARROZZA and 5 paratypes in coll. A. CARCASSI (Cagliari). Type locality. Italy, off Sardinia, 60 km SE of Cagliari, 630 m, in holes made by ship-worms in a piece of sunken drift-wood, 13 specimens.

Material examined. With certainty known from the type material only. Off southwestern Portugal, SEAMOUNT 1 DW41, Josephine Bank, 36°40.1'N, 14°14.9'W, 200 m, (identity uncertain) 3 adult specimens, 1 young and 1 protoconch on a cephalopod beak (MNHN).

**Description.** (Based on the Mediterranean specimens.)

Shell (Fig. 9 A-B). Large for the genus, up to 4-5 mm in diameter, conical, with slightly convex anterior and posterior slopes, rather sturdy, with about 23 radially arranged periostracal ridges. Height slightly more than half the length. The apex is central and its inclination changes very slightly only during its very early growth. The sculpture consists of irregularly scattered, almost perfectly concentric growth lines. Holotype, diameter 3 mm (edges chipped).

Soft parts (Fig. 10 A-C). (Based on a dried specimen, reconstituted in borax-buffered, 10% formaldehyde, transferred to alcohol and critical-point dried.) The foot is large and sucker like, its breadth corresponds to about 90% of the width of the contracted soft parts. It is thin, lacks a propodium, and has no appendages. The head is proportionally large, with a broad, apically expanded snout. The apical part of the snout forms a well defined, flat area with a central mouth and has had a large sucker like shield at each side, broken in the figured specimen due to decay. The head has two cephalic tentacles of equal size, short and stubby, the right one with a latero-dorsal penis, much larger than the tentacle. Distally the penis has a ventral sperm gutter, which proximally may be closed (serial sectioning should be needed). Dorsally at the base, the penis has a small process of a size and shape similar to the cephalic tentacle. The pallial skirt is equipped with numerous gutter like tentacles



corresponding to the periostracal ridges. The gill starts centrally in the anterior part of the pallial cavity, has perhaps 10 leaflets, and continues over to the right side, beside the neck.

**Radula** (Fig. 11 A-C). The central field is reduced but maintains a shield like structure in the center of each transverse row, occasionally and especially in the centre and sides, slightly protruding from the radular membrane. The first fully developed tooth is a tall, laterally flattened structure on a slightly wider base. Next element is low and irregularly shaped, partly concealed between the surrounding teeth. It seems mainly to act as a joint between teeth number 1 and 3. The third tooth is large and sturdy. On its outer side and to some extent covering its outer slope are 3-5 indistinctly set off lamellae which may be a reduced tooth (teeth?).

**Remarks.** The specimens listed above from the Josephine Bank (off southwestern Portugal) are about half the size of *B. xylophagum* and have a proportionally taller shell, but are well preserved and figured here to give a better picture of the morphology of *Bathysciadium* (Figs 8 A-C, 9 C-D, 12 A-B, 13 A-B, 14 A-E). I am not convinced that they are conspecific with the Mediterranean specimens.

A young specimen is figured (Fig. 12A) to show how the relative size of the penis diminishes with increasing size. Its shell is shown in Figure 14D.

On the same squid beak was also found a slightly broken larval shell with soft parts (Fig. 14 A-C, E). It was evidently very recently metamorphosed, because there was no radula present. This larval shell resembles that of *Bathysciadium* sp. in Figure 2 in shape, but it differs considerably in sculpture. I do not know to what extent the difference is caused by corrosion, but it seems to be in a rather good condition. If this really is the protoconch of this species I can here see a possible reason for future subdivision of *Bathysciadium*.

*Bathysciadium xylophagum* differs from *B. costulatum* in its larger size and more depressed shape. It differs from *B. pacificum* in its slightly smaller size and much smaller gill with about 10 leaflets instead of 25.

I have examined a shell of another species of *Bathysciadium*, collected by F. GIUSTI (Livorno). It originates from off Capraia, at a depth of about 150 m, and is figured in Fig. 9 E-F. It differs from *B. xylophagum* by having a relatively taller shell and by being smaller. It can be separated from *B. costulatum* by having an inclining apex and has to remain unnamed until live taken specimens become available.

The substrate of the type series of *B. xylophagum*, from bored wood, is unexpected, but it is possible that many of the deep-sea limpets from biogenic substrates can live on a "second choice", if the first is not available. So have e.g. *Coccapigya spinigera* (Jeffreys, 1883) which normally lives on wood also been found on whale bone (off Iceland, WARÉN unpubl.); the deep-sea mussels *Idas simpsoni* (Marshall, 1900) and *I. argenteus* Jeffreys, 1876 both occur on wood and whale bone (WARÉN 1991, 1993 and unpubl.) although the former

normally lives on whale bone, the latter on wood. MARSHALL (1994: 2) found *Paracocculina cervae* (Fleming, 1948) on both algal holdfasts and whale skulls.

Family ADDISONIIDAE Dall, 1882  
Genus *Addisonia* Dall, 1882

*Addisonia* Dall, 1882: 404. Type species *A. paradoxa* Dall, 1882, by original designation, northwestern Atlantic.

Remarks. The family Addisoniidae and its single genus *Addisonia* were revised by McLEAN (1985) who described a new species from the eastern Pacific. He also reviewed the controversy whether *A. paradoxa* Dall, 1882 from the western Atlantic and *A. excentrica* Tiberi, 1855 from the Mediterranean belong to the same species. McLEAN's conclusion on this was that the problem could not be solved at that time. However, the differences in size between the two, assumed to measure 20 and 10 mm indicated to him that there was reason to keep them apart. (He evidently overlooked the size given by TIBERI in the original description: 17 mm.)

DANTART & LUQUE (1994) presented additional information, and favoured a view that *A. excentrica* and *A. paradoxa* are conspecific. This was based on their finding of large specimens and a record by RAGOZZI (1985) of a specimen of 17 mm.

I have examined material from the East and West Atlantic and one intermediate locality, and can see no difference in the shells. As presented below, the examination of radulae from different localities has also nullified the discrepancies between earlier descriptions, and I can therefore give no reason for separating the two.

The specimens from Irving Seamount and two large adult Mediterranean specimens were also used for examination of the soft parts, resulting in the following additions to McLEAN's (1985) and DANTART & LUQUE's (1994) descriptions:

(Figs 14-17.) The margin of the foot is not double as it is in several other lepetelloids, and there is no trace of a propodium (Fig. 15 A). The margin of the pallial skirt is finely papillose (Fig. 14 B). In the left part of the pallial groove there is a distinct, extra skin-fold parallelling the pallial skirt along the central half of the foot (by DANTART & LUQUE indicated in a more anterior position, in a specimen of 7 mm). The tentacles are wrinkled (by contraction) and have some very small tufts of sensory cilia, but no sensory papillae similar to those in most vetigastropods. I have also critical-point dried three young specimens (0.7, 2.7, and 7.3 mm shell diameter) to see if they showed any characters that were lost or modified during the ontogeny. The 7.3 mm long specimen has a small, bifid "pallial" tentacle on the left part of the pallial margin, at the same level as the most posterior part of the neck (Figs 15 A, C), richly covered by small "warts", possibly of sensory function. It

was absent in the 2.7 mm specimen, and could not be seen in adult specimens. This may be an individual variation.

The gill increases rapidly in size when specimens grow; in a 2.7 mm specimen it consists of 7 leaflets (Fig. 16B) and its length corresponds to 1/5 of the shell; an adult specimen has at least 40 leaflets and it forms a complete half-circle from the head to behind the foot (Fig. 1 A).

The radulae of *Addisonia brophyi* were figured by HICKMAN (1983: figs 10, 38, as "*Addisonia* n.sp.") and McLEAN (1985: figs 15-16). DANTART & LUQUE (1994) gave SEM pictures of the radula of Mediterranean specimens of *excentrica* and pointed out that it (and that of *A. paradoxa*) differs from that of *A. brophyi* in having a "fourth lateral element" which is "thickened" and "finely multicuspidate". They had, however, not examined a radula of the two American species, but concluded this from McLEAN's (1985) photo of the radula of *A. paradoxa* and HICKMAN's (1983) description of the radula of *brophyi*. The radula of *paradoxa* was, however, figured only with a light micrograph, not suitable for comparison, which explains their erroneous statement.

I have examined the radula of *A. excentrica* and *A. paradoxa* with SEM and at it should be mentioned that I found two "small sigmoid elements" in both *A. paradoxa* and *A. excentrica*, not a single. These are marked "3" and "4" in the Figs 19-21. They are present also in *A. brophyi* but in that species tooth number 4 differs slightly in shape and has a more distinct apical tubercle, judging from HICKMAN's fig. 10.

DANTART & LUQUE's fig. 80 shows what they considered the fourth tooth of *A. excentrica*, with six cusps. They compared this tooth with the fourth tooth of *brophyi*, but since they actually compared the fifth tooth of *excentrica* with the fourth one of *brophyi*, this comparison is irrelevant, and tooth number 5 of *brophyi* can be seen in HICKMAN's fig. 13, very similar to tooth number 5 in my Figs 19-20 and DANTART & LUQUE's fig. 80.

Second, there is a vestigial rod like element between the serrated tooth number 5 and the larger bicuspidate tooth (number 7 in my Figs). The formula therefore becomes 9 - 1 - 9. These are numbered 0-9 in Figs 19 B, 20, with the rachidian as number 0. I can see no possibility of allocating any of the teeth to the traditional lateral or marginal fields from their morphology.

Except for overlooking two rudimentary teeth, DANTART & LUQUE's description is good and I refer to it for details of the shape of the teeth. I do, however, figure a complete row of teeth of adult *A. excentrica* from the Mediterranean (Fig. 19 C), a young and two very young specimens (2.7 and 0.7 mm) from the Irving Seamount (Figs 19 B, 20 A), and an adult specimen from Marthas Vineyard (Figs 19 A, 20 B) to show the change with size and that there is no difference in the radula of East and West Atlantic specimens. Fig. 21 shows some further details in the morphology of the teeth and the well hidden tooth number 6 which previously has been overlooked. To this can be added that the radular sac is not bilobed in its posterior end.

Larvae and reproduction. DANTART & LUQUE figured larval shells supposed to belong to *Addisonia* (figs 73-76). These are amazingly similar to those of some undescribed Lepetellids whose identity I have confirmed by radular examination, more so than most lepetellid protoconchs I have seen, which have more distant axial and radial ribs. I am therefore not completely convinced that DANTART & LUQUE's larval shells are correctly identified. If they are, as seems likely from being found inside egg cases, they may indicate very close relations between the families.

*Addisonia paradoxa* is said to be a hermaphrodite (McLEAN 1985, HASZPRUNAR 1987, 1988), evidently because specimens have an ovary and a sperm groove on the right cephalic tentacle (Fig. 15). This has not been fully described and the possibility that they may be protandrous and simultaneous hermaphrodites (i.e. they start as males and add female characters at a later stage) needs to be investigated.

DANTART & LUQUE (1994) described parts of the biology which can be summarised: *Addisonia excentrica* normally lives in empty egg cases of sharks - mainly *Scyliorhinus canicula* (L.) - and skates. Two specimens were, however, recorded "free" on the bottom. Infestation rates varied between 10 and 50% of the capsules in Mediterranean Spain, with usually 2-6 (maximum 26) gastropods per egg case. One, rarely two of these specimens, were adult. In a single case *A. excentrica* occurred in an egg case with an undamaged shark embryo.

VILLA (1985), GUBBIOLI & NOFRONI (1986), and NOFRONI (pers. comm.), found four to six small and/or a single large specimen in each inhabited egg case (35 cases [14%] infested of 250 examined. Occasionally there were two big specimens present in an egg case, but then one was dead [present as shell]). Infested egg cases have thinned areas (feeding tracks) and small oval holes 0.3 x 0.2 mm diameter, which have been made from the inside, and are thus not entry holes.

This useful information helps to understand the morphology and the taxonomy of *Addisonia*. I complete it with some observations on a skate egg capsule from Irving Seamount (see "material examined" under the specific heading). This case contained four specimens of *Addisonia*: one evidently adult specimen, diameter 15 mm, in the centre of the capsule; one half-grown specimen of 7.3 mm; one young of 2.3 mm, both close to the edge of the capsule; and finally a very young specimen of 0.68 mm diameter, buried in a deep pit. Shell proportions differ between the two largest specimens, the 7.3 mm specimen being proportionally much flatter than the large one, also when compared to the corresponding growth stage of the large specimen. This is a variation I have also seen when examining scattered specimens from various sources.

I believe this to be an individual, phenotypic adaptation to the space available in the capsule. When there is a single individual there are no spatial constraints and it uses the central part. If additional individuals settle they

become forced to use the space close to the edge, not used by the first (and larger) coloniser. Whether or not this is combined with protandry, i.e. that the small specimens are males only, I have not had material to determine.

Another interesting fact is that the very young specimen mentioned above had excavated a deep pit (eventually the holes mentioned by DANTART & LUQUE), in which it was sitting. The volume of this pit corresponded to 10-20 times its body volume. Adult specimens have not consumed such quantities of the egg cases in which they are found; instead, these are remarkably undamaged. This raises the question -- is there a drastic change in the way the snails use the material of the cases during their life?

The habit of living in old shark and skate egg cases certainly affords these limpets both a good protection and also a source of nourishment that must be quite stable and predictable when the larva has found it. *Scyliorhinus canicula* takes up to 300 days for the development in the capsule (THOMASON *et al.* 1994). Probably the cases remain for long after the young have hatched, since most egg cases one finds are empty (A.W. pers. obs.). Furthermore, the cases have been shown to contain antifouling agents (THOMASON *et al.* 1994) that keep epifauna away and presumably make the cases less appealing to scavengers that are not as specialised as *Addisonia*.

*Addisonia excentrica* (Tiberi, 1855)

*Gadinia excentrica*: TIBERI, 1855: 13, plate 2, figs 5, 6.

*Gadinia excentrica*: TIBERI 1857: 37, plate 2, fig. 2.

*Addisonia paradoxa*: DALL, 1882a: 405.

*Addisonia lateralis*: DAUTZENBERG 1886: 203 (not REQUIEN, 1848).

*Addisonia lateralis*: THIELE 1908: 88, figs 4-6, 9-11.

*Addisonia lateralis*: MCLEAN 1985:103, figs 3-4.

*Addisonia excentrica*: DANTART & LUQUE 1994:293, figs 68-88.

Type material. *G. excentrica*, one syntype in MNHN (TIBERI mentioned 4 specimens in the original description); *A. paradoxa*, lectotype (MCLEAN 1985:101) USNM 43741.

Type locality. *G. excentrica*, "Coral bottoms", Sardinia and Gulf of Naples; *A. paradoxa*, Massachusetts, off Martha's Vineyard Island, 126 m.

Material examined. The syntype mentioned above. Several specimens from off Malta and the Tuscan Archipelago from Italian amateur collections. Seamounts off southwestern Portugal, 300-1200 m, many shells. South of the Azores, SEAMOUNT 2, station CP 210, Irving Seamount, 32°02.4'N, 27°56.8'W, 320 m depths, 4 specimens in a skate egg case. Off Guinea Bissau, Chagos Archipelago, 180-259 m depth, 1 specimen (reported by LUQUE & DANTART 1994).

Distribution. Eastern Atlantic-Mediterranean: Italy, southwest of Rome,

Fiumicino, in skate egg case (VILLA 1885). Spain, Marbella and Tetuan, Morocco, in skate egg cases (GUBBIOLI & NOFRONI 1986). Sicily to Corsica in the Mediterranean; Bay of Biscay to Morocco and Guinea Bissau (DANTART & LUQUE 1994, McLEAN 1985). Western Atlantic: Grand Banks off Nova Scotia to off Jamaica (McLEAN 1985 as *A. paradoxa*). Mid-Atlantic Ridge, Irving Seamount (herein). Depth range 80 - 1200 m.

Remarks. DANTART & LUQUE *et al.* (1994) gave good reasons for abandoning the specific name *Addisonia lateralis* (Requien, 1848), namely that Requien's name was based on *Trimusculus mamillaris* (Linnaeus, 1758) (Pulmonata, Siphonariidae). However, they overlooked TIBERI's earlier description (1855) in a pamphlet (see FISCHER 1857).

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I also want to thank F. Carrozza (Soiana, Italy) and A. Carcassi (Cagliari) who discovered *Bathysciadium xylophaga* and realised what they had found but were too modest to accept coauthorship of this paper.

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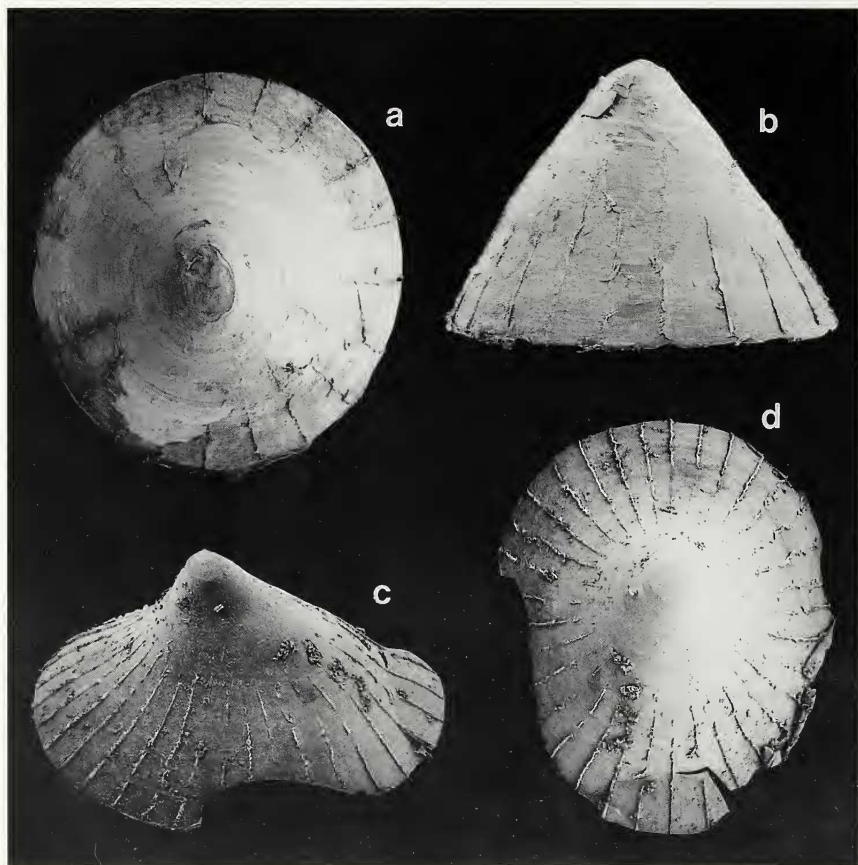


Figure 1 **A-D**. *Bathysciadium* spp., shells. **A-B**. *B. costulatum*, syntype, diameter 1.73 mm. **C-D**. *Bonus petrochenkoi*, Kuril-Kamchatka Trench, 43°47'N, 149°43'E, 9130-9430 m, paratype, diameter 2.7 mm.



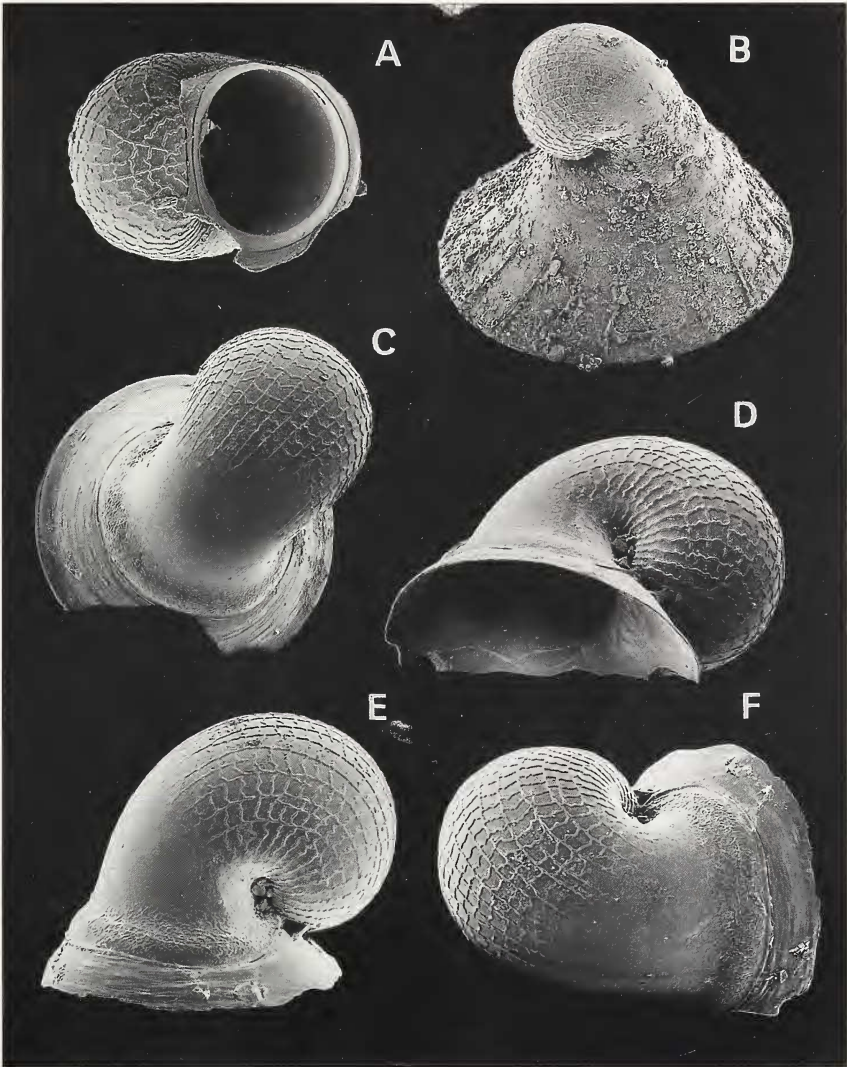


Figure 2 A-F. *Bathysciadium* sp., off Reunion Island, MARION DUFRESNE Cruise 32, CP146, 20°32.7'S, 55°40.9'E, 2830-2850 m, protoconchs. A. With traces of teleoconch, diameter 245  $\mu$ m. B. Largest specimen with protoconch left, diameter of teleoconch 0.74 mm. C. Width of teleoconch 0.48 mm. D. Young specimen, lateral view, diameter of teleoconch 250  $\mu$ m. E. Young specimen, diameter of teleoconch 250  $\mu$ m. F. Front view, diameter of teleoconch 250  $\mu$ m.

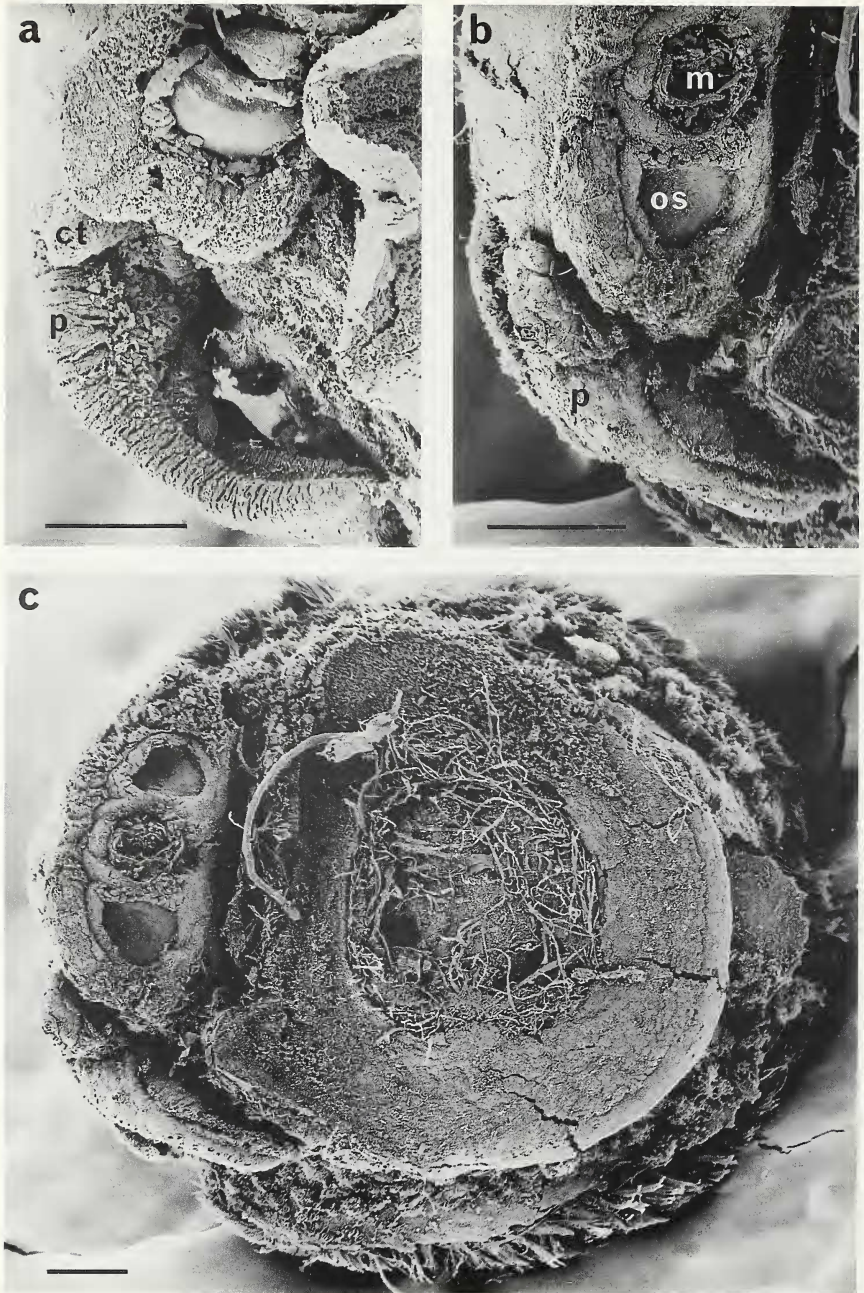


Figure 3 A-C. *Bathysciadium costulatum*, critical-point dried. **A.** DISCOVERY station 7991, ventral view of head. Oral "sucker" destroyed. **B-C** - Syntype of *B. conicum*. Legend: ct - cephalic tentacle; m - mouth; os - oral "sucker"; p - penis. Scale lines 100  $\mu$ m.



Figure 4. *Bathysciadium conicum*, DISCOVERY 7991, diameter 1.1 mm. Notice the cephalic tentacles at the white arrows. Scale line 100  $\mu\text{m}$ .

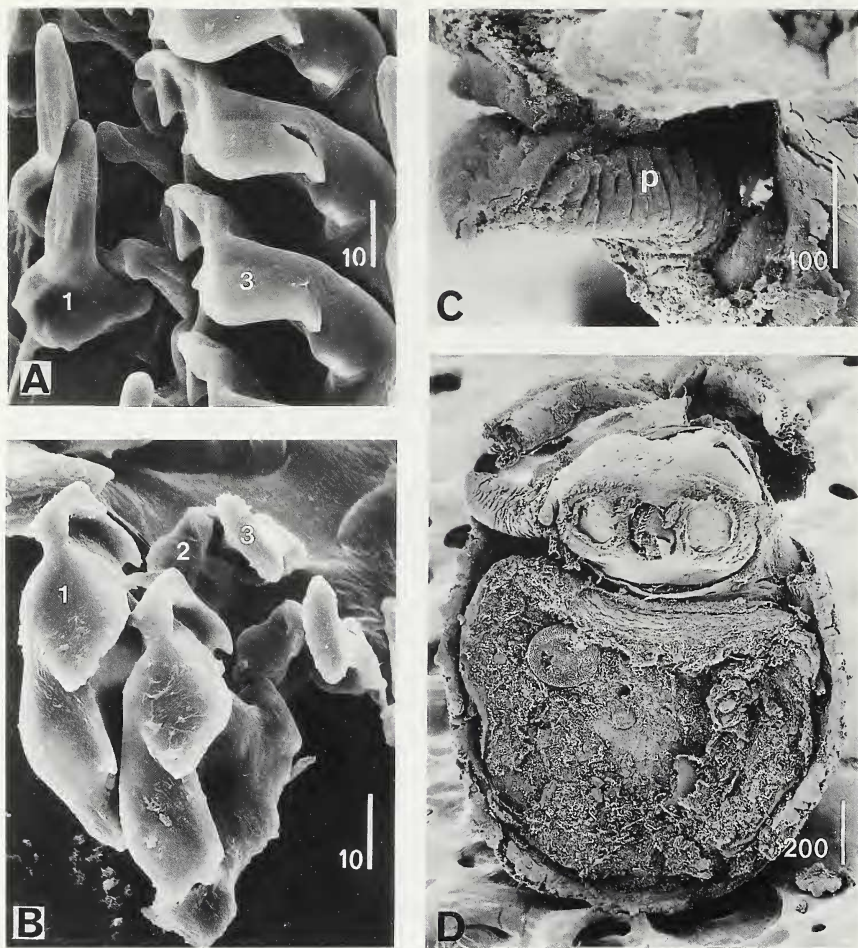


Figure 5 A-D. *Bathysciadium* spp., radulae and critical-point dried. A. *B. pacificum*, from Moskalev, off Peru, 08°24'S, 80°11'W, 580-570 m, from two beaks of *Dosidiscus gigas*. Tooth number 2 between 1 and 3, not numbered. B-D. *B. petrochenkoi*, paratype, Kuril-Kamchatka Trench, 43°47'N, 149°43'E, 9130-9430 m, showing tooth number 2. C. Penis (p). D. Body, ventral view. Scale lines in  $\mu\text{m}$ .

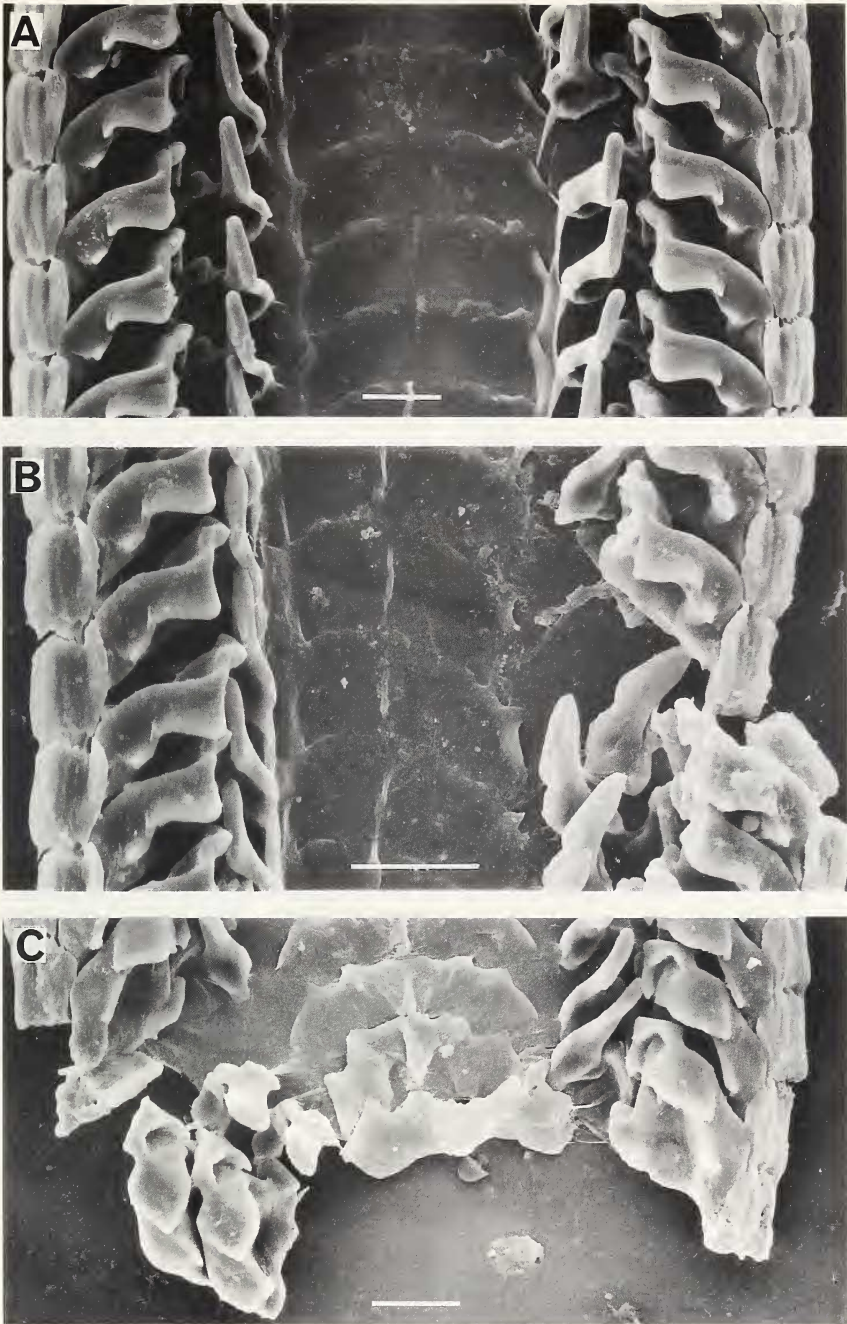


Figure 6 A-C. *Bathysciadium* spp., radulae. A. *B. pacificum*, off Peru, 08° 24'S, 80° 11'W, 580-570 m, from two beaks of *Dosidiscus gigas*. B. *B. conicum*, MONACO Expeditions, station 244. C. *Bonus petrochenkoi*, paratype, Kuril-Kamchatka Trench, 43° 47'N, 149° 43'E, 9130-9430 m. Scale lines 200  $\mu$ m.

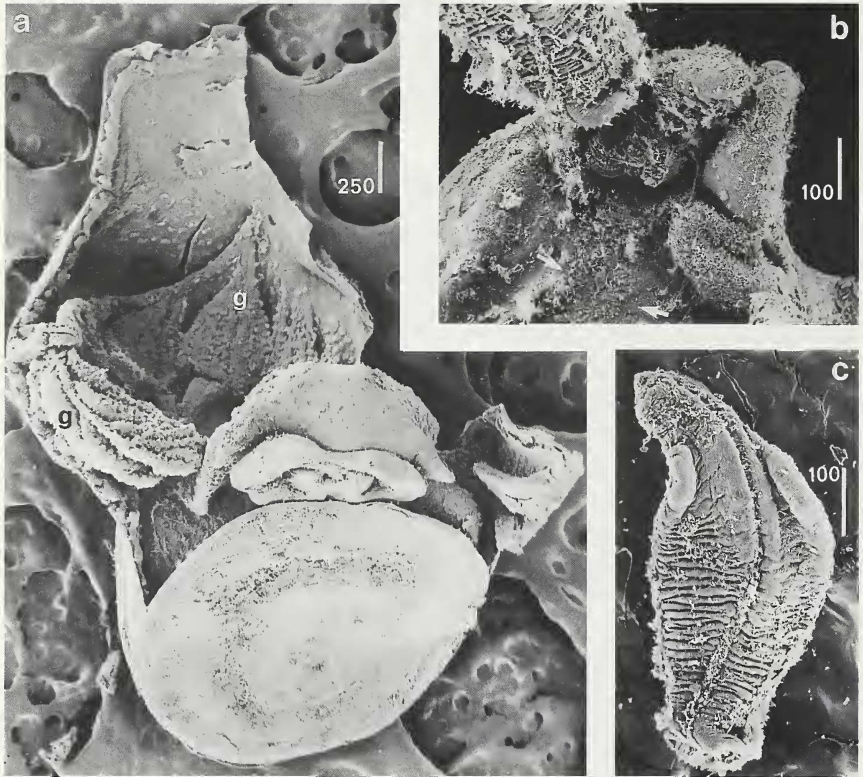


Figure 7 A-C. *Bathysciadium pacificum*, off Peru, 08°24'S, 80°11'W, 580-570 m, from two beaks of *Dosidiscus gigas*. A. Complete specimen, Pallial cavity opened. B. Lateral view of head, penis partly broken off. Ciliated tract between the white arrows. C. Penis, ventral view. Legend: g - gill. Scale lines in  $\mu\text{m}$ .

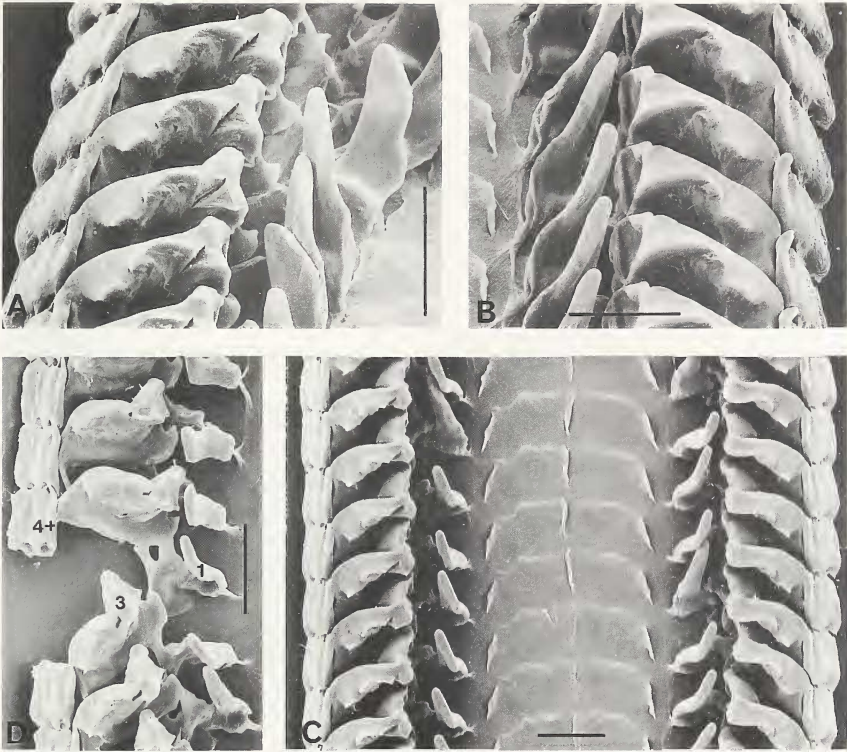


Figura 8 A-D. *Bathysciadium* spp., radulae A-C. *B. cf. xylophagum*, SEAMOUNT 1 DW41. A. Oblique view. B. Vertical view. C. Complete width. D. *B. costulatum*, syntype. Scale lines 20  $\mu$ m

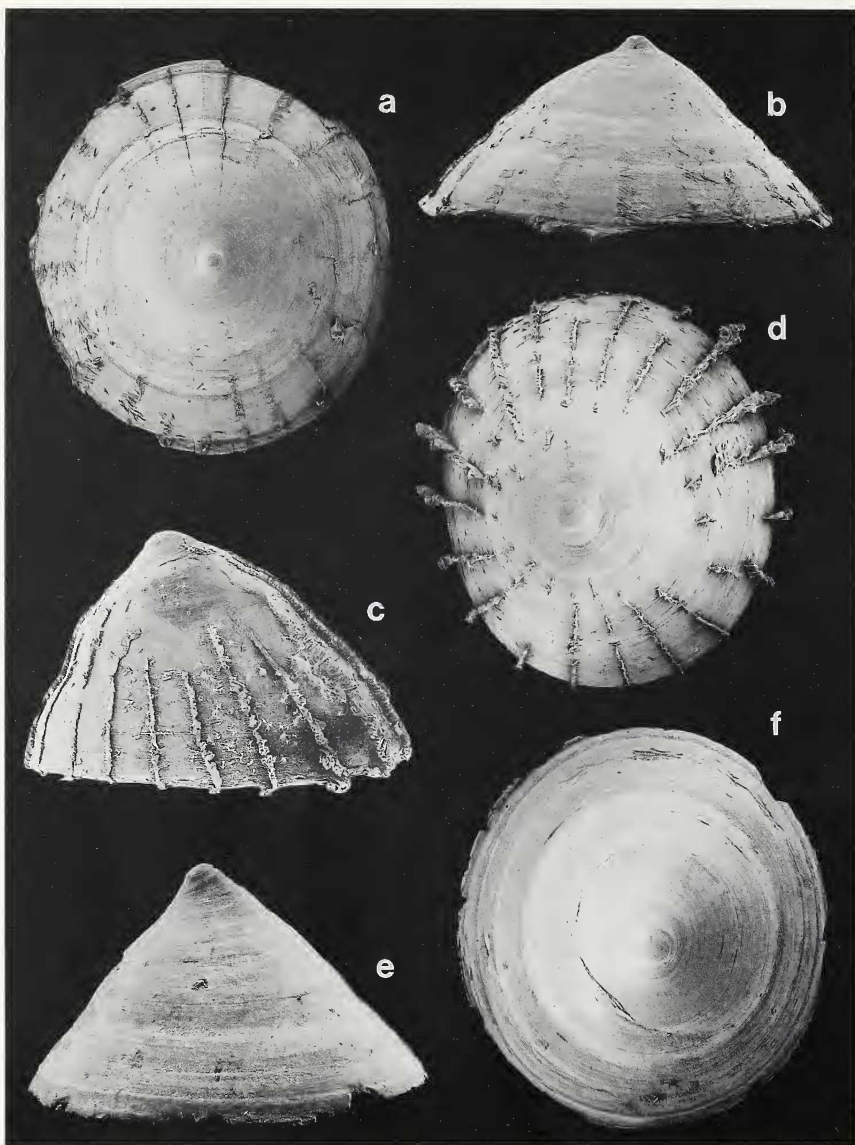


Figure 9 A-F. *Bathysciadium* spp. shells. A-B. *B. xylophagum*, paratype, 3.9 mm. C-D. *B. cf. xylophagum*, SEAMOUNT 1 DW41, 2.0 mm (side), 2.3 mm (apical view). E-F. *Bathysciadium* sp., off Capraia, 150 m, 2.0 mm diameter, coll. F. Giusti.



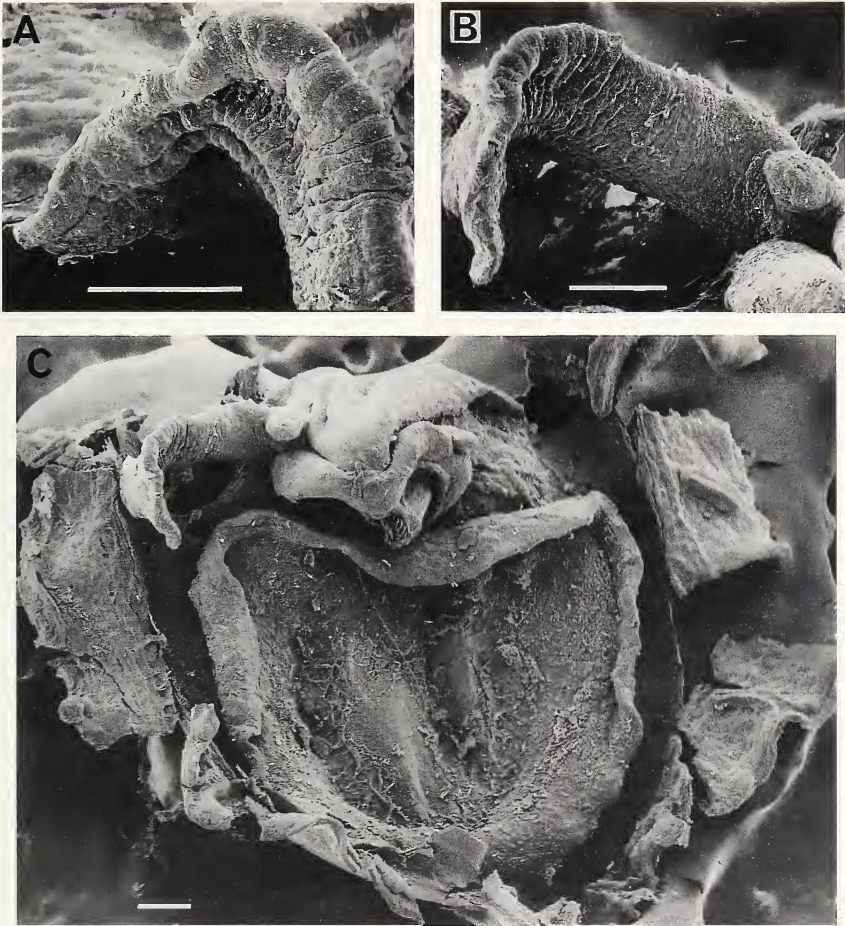


Figure 10 **A-C.** *Bathysciadium xylophagum* paratype. **A.** Penis, ventral view, with open sperm groove. **B.** Penis, more posterior view. **C.** Complete specimen, mantle cavity partly opened. Oral "suckers" "caved in". Scale lines 200  $\mu\text{m}$ .

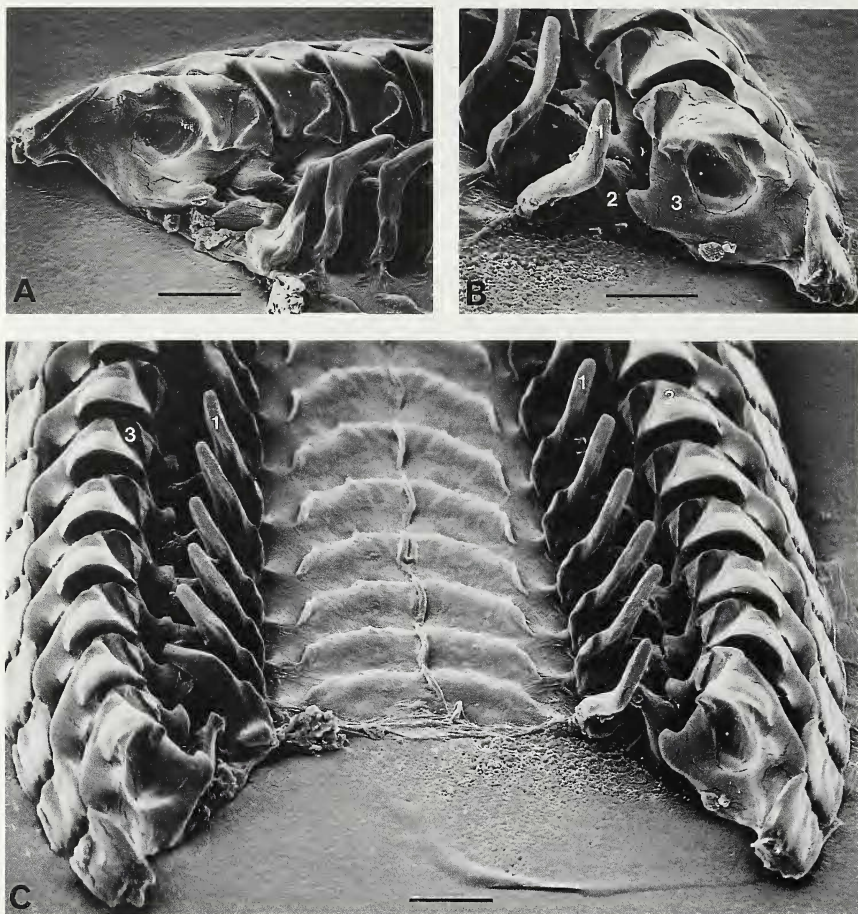


Figure 11 A-C. *Bathysciadium xylophagum*, paratype, radula. A-B. Lateral field, oblique view. C. Complete width. Scale lines 20  $\mu$ m

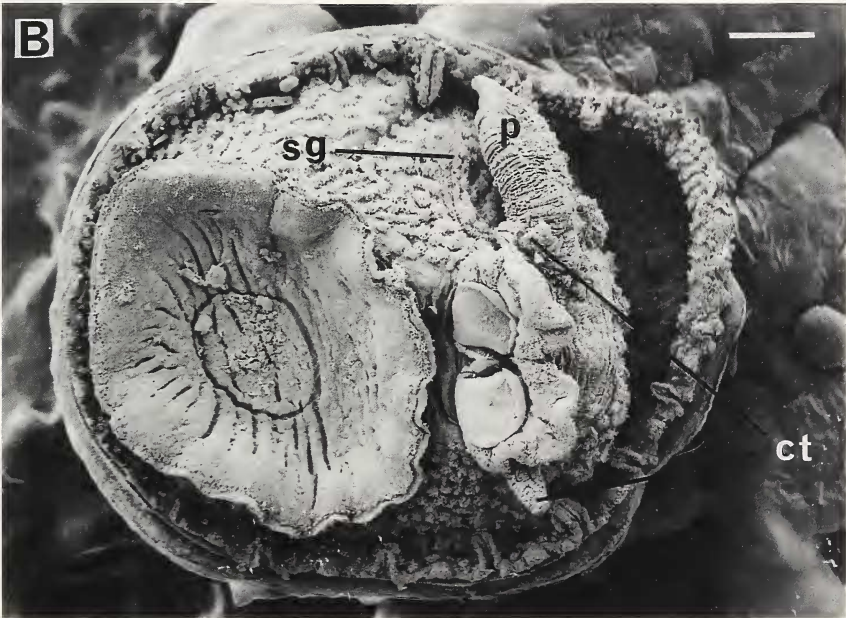


Figure 12 A-B. *Bathysciadium* cf. *xylophagum*., critical-point dried, SEAMOUNT 1 DW41. A. Young specimen. B. Adult specimen. Legend: ct - cephalic tentacle; p - penis; sg - seminal groove. Scale lines 200  $\mu$ m.

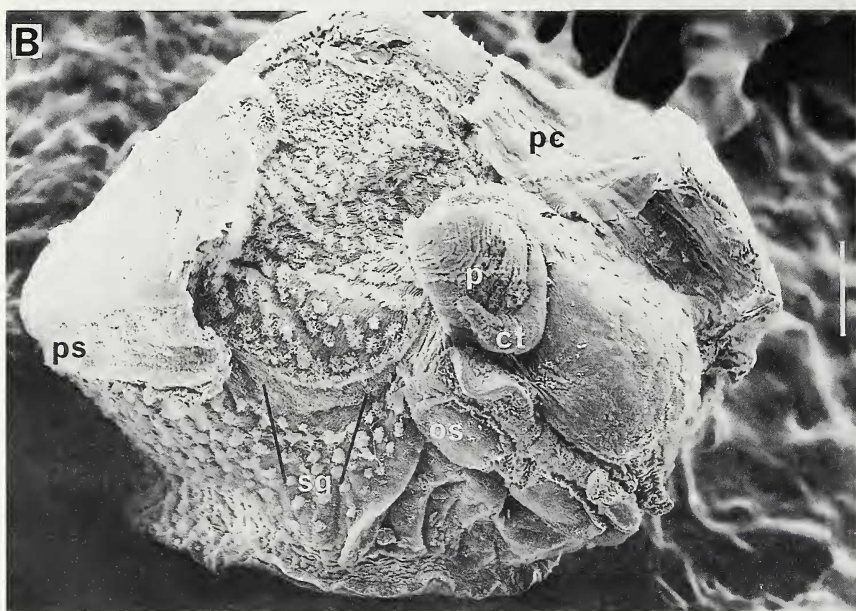


Figure 13 A-B. *Bathysciadium* sp., critical-point dried, SEAMOUNT 1 DW41. A. Pallial skirt of specimen in Fig. B, with gill and opened pericardium with ventricle and aorta. Tip of gill broken and showing gill vessels. B. Adult specimen, pallial skirt removed. Legends: ct - cephalic tentacle; os - oral sucker; p - penis; pc - pericardial cavity; sg - seminal groove; v - gill vessel; ve - ventricle. Scale lines 200  $\mu$ m.

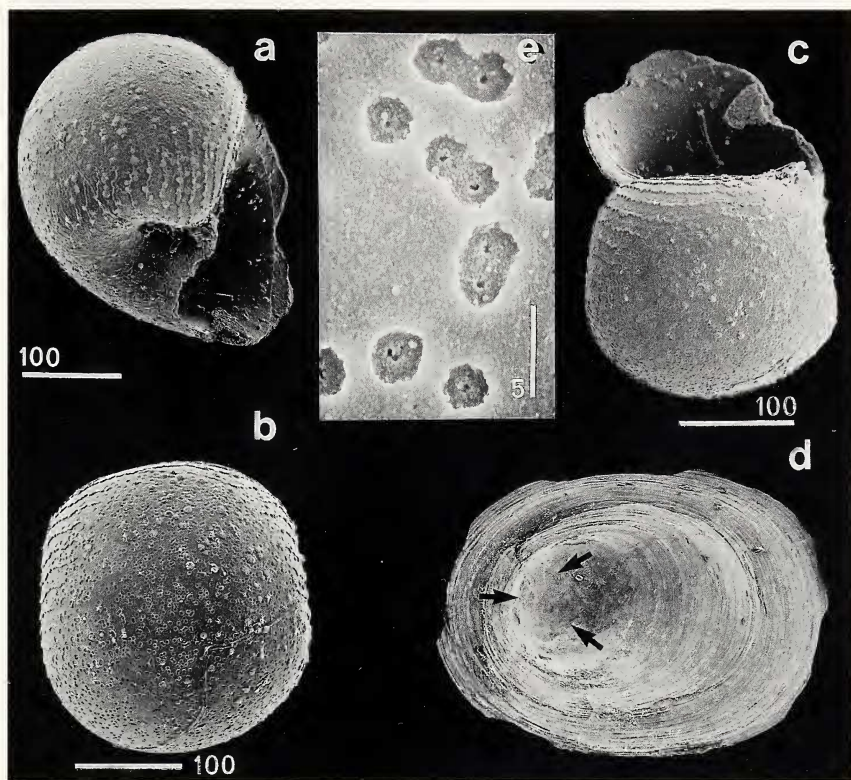


Figure 14 A-E. *Bathysciadium* cf. *xylophagum*, SEAMOUNT 1 DW41, ontogeny. A-C. Protoconch, different views. D. Young specimen, diameter 0.88 mm. Arrows indicate the scar from protoconch. E. Micro sculpture. Scale lines in  $\mu\text{m}$ .

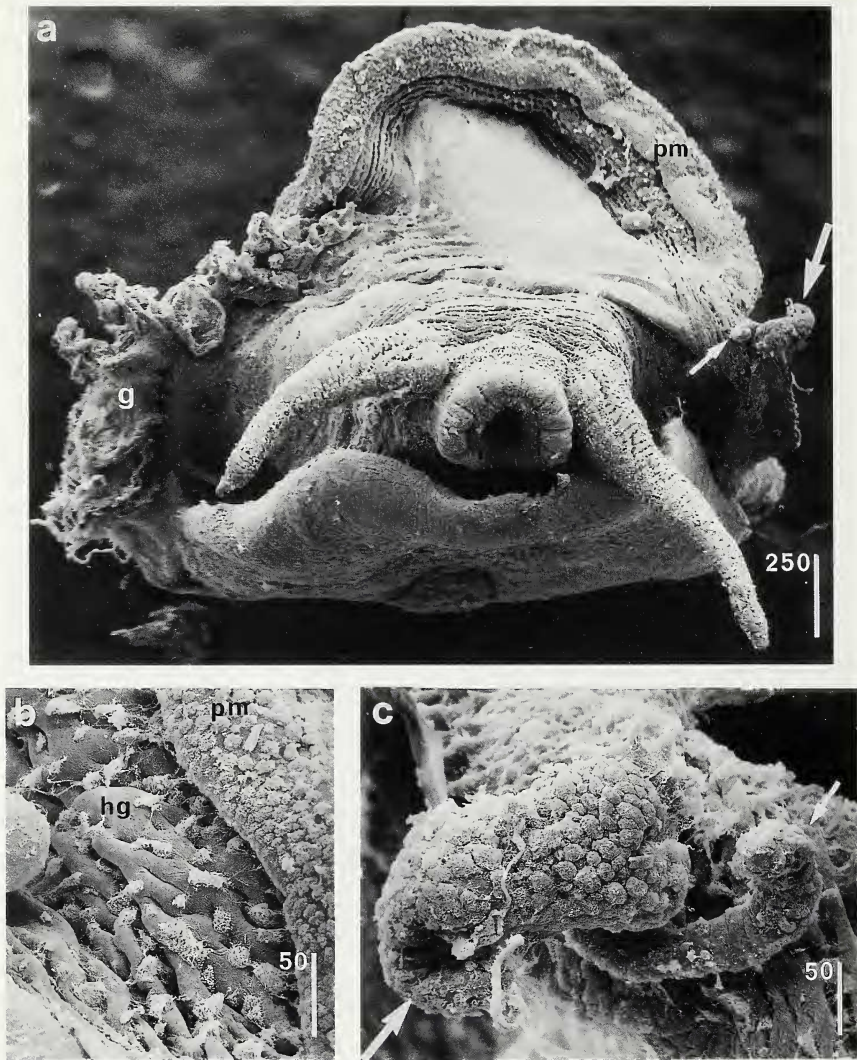


Figure 15 A-C. *Addisonia excentrica*, critical-point dried, SEAMOUNT 2 DW210, shell diameter 7.3 mm. **A.** Anterior view, pallial skirt folded back. **B.** Detail of pallial skirt and hypobranchial gland. **C.** Detail of pallial appendix. Legends: g - gill; hg - hypobranchial gland; pm - pallial margin; pallial tentacles indicated with small and large white arrows. Scale lines in  $\mu\text{m}$ .

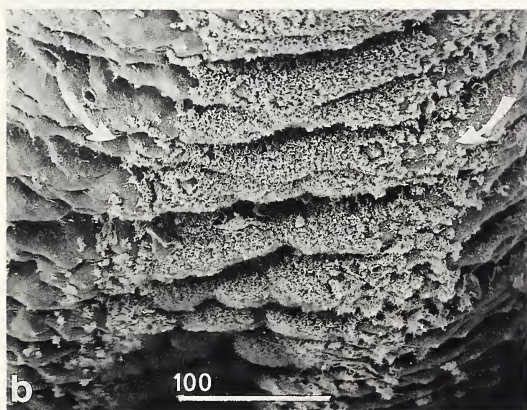
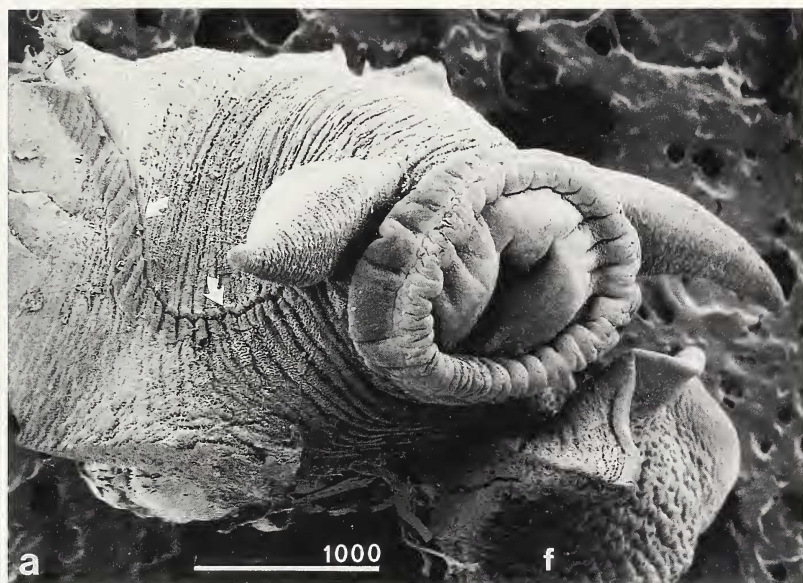


Figure 16 A-C. *Addisonia excentrica*, head of adult specimen, shell diameter 15 mm, SEAMOUNT 2 DW210. A. Head, part of anterior edge of foot left. B. Detail of sperm tract on cephalic tentacle. C. Neck and cephalic tentacle with sperm tract. Legends: Sperm tract marked by white arrows; f - foot. Scale lines in  $\mu\text{m}$ .

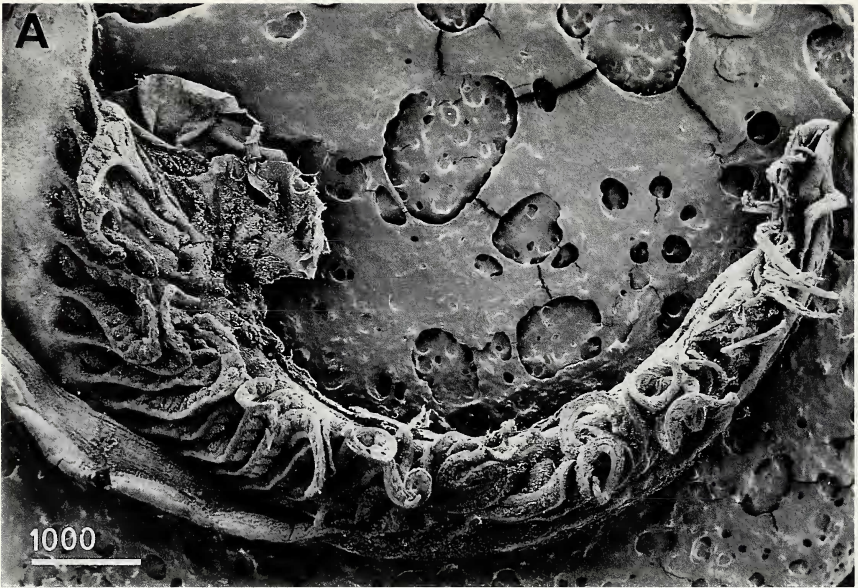


Figure 17 A-B. *Addisonia excentrica*, critical-point dried, SEAMOUNT 2 DW210. A. Gill of adult specimen, shell diameter 15 mm, attached to pallial skirt. B. Young specimen, shell diameter 2.6 mm. Notice the short gill and the seminal tract indicated by arrows. Scale lines in  $\mu\text{m}$ .



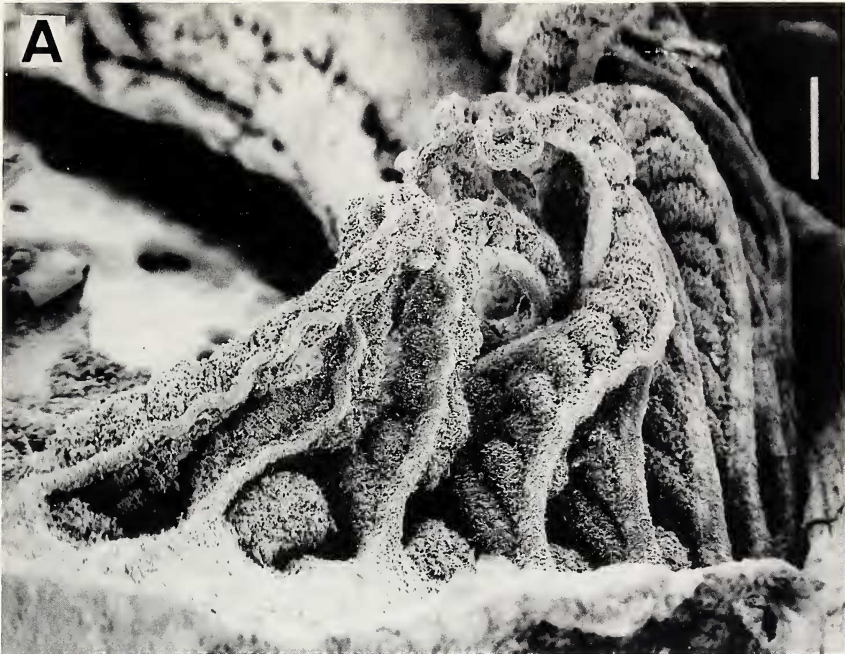


Figure 18 A-B. *Addisonia excentrica*, critical-point dried, SEAMOUNT 2 DW219, detail of gill. A. Anterior view of anterior leaflets. B. Lateral view of anterior leaflets. Legends: pm - pallial margin; ps - pallial skirt. Scale lines 250  $\mu$ m.

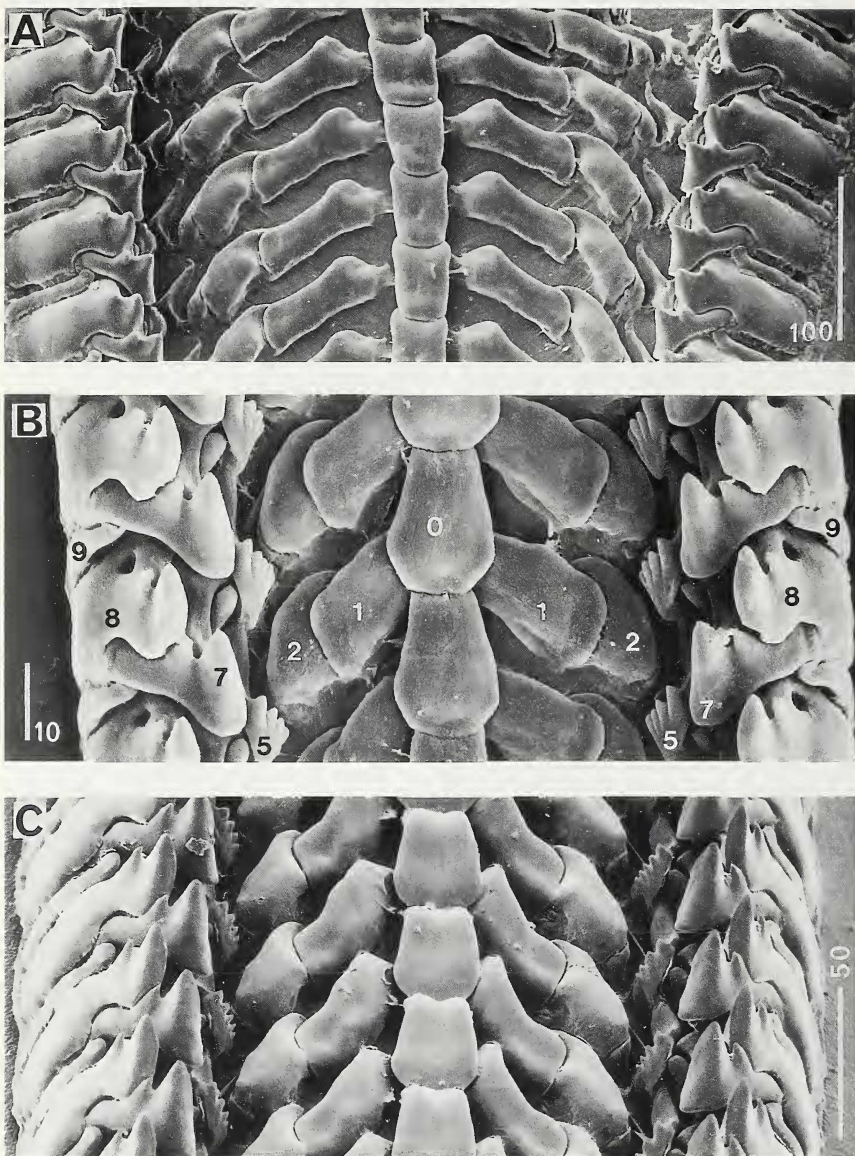


Figure 19 A-C. *Addisonia*, radulae, whole width. A. *A. paradoxa*, syntype, USNM 43743, ca 14 mm shell diameter. B. *A. excentrica*, SEAMOUNT 2, DW210, 2.6 mm shell diameter. C. *A. excentrica*, Tuscan Sea, San Andrea, 12 mm shell diameter. 1-9 indicates the order of the teeth, with rachidian as 0. Scale lines in  $\mu\text{m}$ .

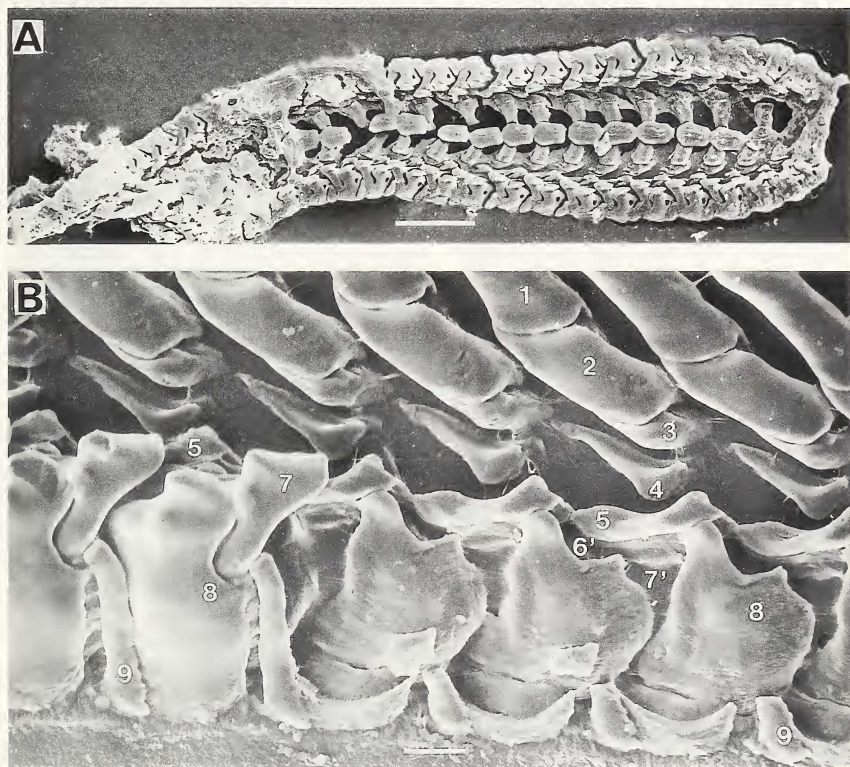


Figure 20 **A-B.** *Addisonia* radula, complete and formation. **A.** SEAMOUNT 2 DW210, length of shell 0.7 mm. **B.** *B. paradoxa*, syntype, USNM 43743, early part of radula. Legends: 6' and 7' indicates where these teeth will be formed. 1-9 indicates the order of the teeth, with rachidian as 0. Scale lines 20  $\mu$ m.

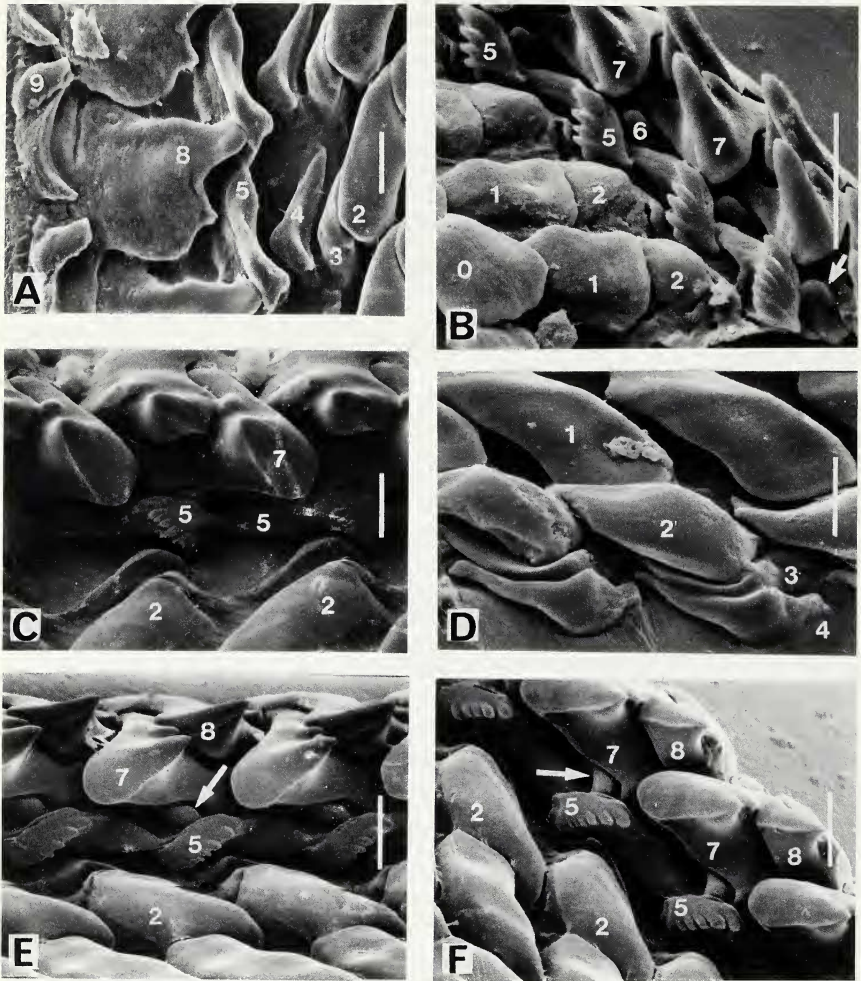


Figure 21 A-F. *Addisonia radula*, details. A. *A. paradoxa*, syntype, USNM 43743. Incompletely formed part of radula for comparison. B. SEAMOUNT 2 DW210, 2.7 mm. C. *A. paradoxa*, syntype, USNM 43743. D-F. Tuscan Sea, San Andrea, coll F. Carrozza. Legends: 1-9 indicates the order of the teeth, with rachidian as 0. Tooth number 6 indicted by a white arrow. Scale lines 20  $\mu$ m.